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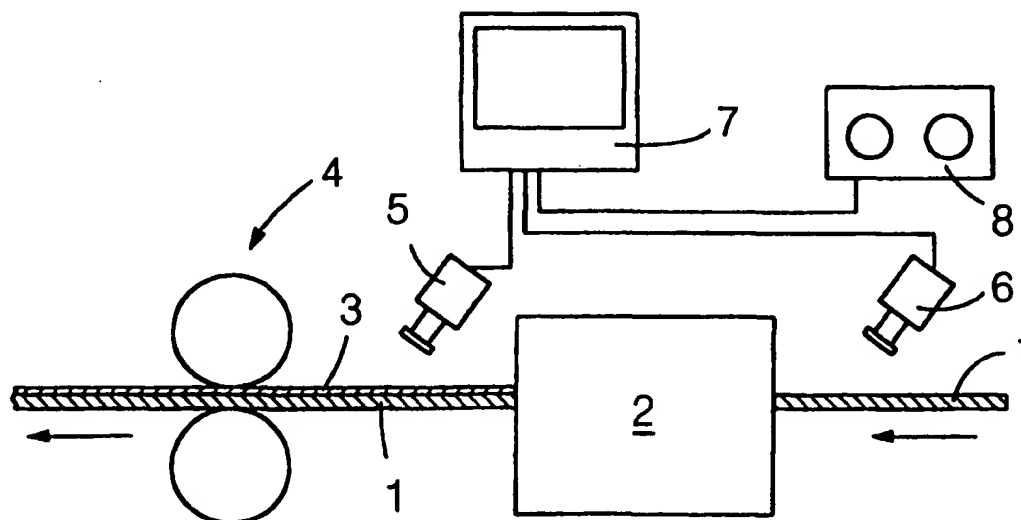
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(54) Title: METHOD FOR MONITORING QUALITY OF PAPER WEB



(57) Abstract

A method for monitoring the quality of a paper web in a continuous process. In the method, a moving paper web is imaged with a thermal camera, whereby the web areas that differ from the moisture level of the surrounding areas or the areas whose coating differs in quantity from the rest of the coated web can be detected in the thermal camera image, and on this basis the process can be controlled to achieve a better end result.

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METHOD FOR MONITORING QUALITY OF PAPER WEB

The invention relates to a method for monitoring the quality of a paper web in a continuous process, wherein the paper web exiting the actual paper machine is conveyed for treatment.

5 Depending on the final use of the paper, a paper web to be manufactured on a paper machine can be treated in a variety of ways even when the web is relatively dry. For instance, when manufacturing common newsprint, its surface is smoothed with a so-called machine calender, whereby sufficient surface smoothness for printing is achieved quickly and economically
10 without coating. Certain magazine paper grades in turn require coated paper, whereby the paper web is coated with coating paste containing e.g. china clay or talcum. Very often the coated paper grades are also calendered, i.e. smoothed after coating.

 Currently, the paper web calendering and/or coating poses a number of quality problems which result in products that are of poor or varying
15 quality, or worse still, in damaging the coater, particularly the calender rolls thereof, which further results in interruptions in production and repair costs.

 In online calendering the web, such as paper, is smoothed as it exits the actual paper machine. In online coating the web is coated as it is produced, i.e. the produced web exiting the paper machine is conveyed directly to
20 coating and further to calendering to the effect that the final result is a finished coated web.

 Frequent problems with the web are wet spots and patches where the web is unbroken but wet. These result in web curling and waviness in the
25 final product. Likewise, in conjunction with coating, problems with runability and consequently interruptions in production occur. A further consequence is a small-scale variation in amounts of coating, which results from the fact that the coating attaches to the dry web in a different manner than to wet spots, and the variation being irregular, it does not even show in laboratory tests. Moreover,
30 in the worst case, one consequence may be that in the wet area the coating will not adhere to the web serving as base paper, but it will detach in calendering stage and stick to the surface of a calender roll, and as a result, a hot area forms on the roll having a polymer surface and destroys the roll's surface material.

35 Furthermore, narrow, less than 10 mm wide, wet streaks appear in the web, as a result of which the paper web shrinks unevenly, and conse-

quently the runability through the whole paper machine, also the coater and later the cutters, deteriorates and waves may form in sheet piles. A further consequence is that amounts of coating vary in different ways in coating and that produces streakiness in the final product. Also in this case the coating at the streaks may adhere to the calender rolls, as a result of which the roll's surface material heats up locally and will be completely destroyed.

Irregular and quick deviations may also occur in coating, which are a common cause of quality variations in coated papers. In post-coating calendering, the coating material may also stick to the calender rolls, since drying is commonly carried out according to an average amount of coating. With time, this may also damage the roll's surface material and lead to a roll change. The CD or MD profile of the paper may also vary excessively. These profile defects may be produced in the wire section, due to wire or felt congestion, in the press section, e.g. by the action of fouled press rolls. These affect the paper formation and thereby the paper profile. In the drying section, suction rolls may produce streaks in the web and thereby affect the profile.

Defect detectors used in paper mills are often based on visible light or on measuring the temperature and moisture of the web. These measurements are typically performed with slow, spot-like sensors. These enable monitoring of long-term variations in the web, but quickly changing defects and deviations remain unnoticed in practice.

German Patent DE 19 63 2988 discloses a solution, in which clearly visible defects, such as tears, light or dark spots, etc., are sought in the web with a conventional video camera by means of bright light. Said publication also discloses a solution, in which the web is monitored either by a conventional IR sensor beam or conventional CCD cameras in order to find similar defects visible to the naked eye and to mark them in the web by spraying marking substance at defects. However, these solutions described in the publications do not allow monitoring moisture defects in the web or variations in the amounts of coating, both of which are often extremely harmful.

The object of the present invention is to provide a method by which the web quality can be monitored more reliably than previously and the causes of various defects can be found in fault situations, whereby they can be eliminated. The method of the invention is characterized in that the moving paper web is imaged with a thermal camera prior to and/or during the treatment substantially continuously in order to detect defects in the paper web and that on

the basis of the detected defects the manufacturing process of the paper web process is adjusted.

The basic idea of the invention is that before and/or after coating the web is monitored substantially continuously with a camera operating within an infrared region, preferably from 3 to 12 micrometer in wavelength. Monitoring can be implemented both as continuous imaging displayed on a monitor and as recording of a camera image such that when a defect or a possible damage appears, it is possible to find the cause of said defect in order that it could be eliminated in one way or another. One preferred embodiment of the invention employs a camera that shows a continuous, non-stop picture of the target to be imaged. Another preferred embodiment of the invention employs a camera that takes a so-called still picture of the target to be imaged at suitably frequent intervals to the effect that if a defect appears it can be rapidly handled. In particular, the invention is applicable to quality control of the web that is already coated or is being coated.

The invention has an advantage that the quality of the finished web product can be ensured. At the same time, it is possible to get quick information on deviations occurring in the process and on the basis thereof the process can be quickly adjusted. Likewise, in situations which may have serious consequences the process can be stopped, the calender opened quickly, if necessary, et cetera, in order for the costs to remain as low as possible. The method of the invention further allows detecting possible, dangerous deviations in the web in conjunction with online calendering and thus localizing the origin of the deviation.

The invention will be described in greater detail in the attached drawing and images, wherein

Figure 1 shows a schematic view of equipment applicable to the implementation of the method of the invention;

Figures 2a and 2b are images of quality deviations in an uncoated web detected with the equipment of Figure 1;

Figure 3 shows deviations in the uncoated web detected after so-called intermediate calendering;

Figure 4 shows the web at the coating station; and

Figure 5 shows the coated web.

Figure 1 is a schematic view of equipment applicable to the implementation of the method of the invention. In the figure, an uncoated web 1 ex-

iting a paper machine is conveyed to a coating unit 2. In the coating unit 2, a coating 3 is applied onto the surface of the web 1, whereafter the coated web is conveyed to calendering 4 and therefrom to further processing. In the coating unit, which is known per se and obvious to the person skilled in the art, coating is applied on the web and spread such that the coated surface of the web is substantially even. In calendering, the coated web is conveyed between hot rolls such that it becomes as even as possible and dries further. In general, the calender rolls are coated with a polymer surface material that is sufficiently elastic and enables even pressing during the calendering.

To implement the method of the invention, the equipment comprises one or more cameras 5 and 6 operating within the infrared region. With these cameras the web 1 can be imaged before or after coating. From the camera or cameras 5,6 the image is conveyed to a monitor 7, for instance, which the operation controller of the equipment can watch. Additionally or alternatively, the image can be conveyed to a recorder 8 which records the image provided by the camera or cameras substantially continuously.

When deviations of a given type, such as wet spots or patches, streaks of moisture, etc., are detected in the web 1 or irregularities are detected in the amount of coating, the process can be immediately adjusted or stopped, if there is any reason to assume that the detected defects would cause serious damage and thereby costs to the equipment. On the basis of the deviations and defects it is further possible to trace the origin of the deviation and hence the quality of the process and its end product can be improved and the interruption and damage costs incurred can be avoided considerably.

Figures 2a and 2b show defects detected with the equipment of Figure 1. The images have been taken of the web 1 in the manner according to the invention, i.e. of the base paper before it is conveyed to a coating station. Figure 2a shows how the moisture level of the web exiting an unserviced machine, for instance due to congested felts, is high and variations are considerable. Conventional online paper measuring devices based on spot detection cannot detect these defects. Instead, from Figure 2b it appears that moisture variations are minor, which indicates that the felts and the paper machine are serviced and in good condition.

Figure 3 shows narrow streaks of moisture in the web 1, i.e. in the base paper. This image was taken of the web 1, i.e. the base paper, after so-called intermediate calendering, and the narrow streaks of moisture indicated

by a reference numeral 9 are clearly visible. Black spots, indicated by a reference numeral 10, also appear in the image, which reveal irregular quality deviations in the web 1.

Figure 4 shows the web, i.e. the base paper, at the coating station, and the image reveals a plurality of different facts. Striping caused by the rolls is indicated with the reference numeral 9 like in Figure 3. A marking 11 caused by a felt seam appears also from the image. A pattern 12 produced by latex spots on the opposite side of the web appears also from the image, which indicates defects in the coating.

In Figure 5, the amount of coating varies in different parts of the web. In this case, there is clearly more coating in some areas than in others, and consequently, the coating dries more slowly in said areas than elsewhere in the paper. As a result, the coating may still be too wet in calendering, whereby the coating may stick to the calender roll's surface that will damage completely with time.

The images used by way of example were taken by a camera operating within an infrared region of 3 to 12 micrometer in wavelength. The measuring regions are preferably from 3 to 5 micrometer or 8 to 12 micrometer, whereby various defects and deviations can be detected in a variety of ways. However, it is essential that by using a thermal camera operating within the infrared region in this manner various defects and deviations can be detected both in the uncoated web and in the coating material of the coated web, which defects and deviations may cause quality variations in the product or even damage to the coating equipment, in particular, in the calender roll's surface material and thus inflict considerable expenses on production, both as downtime and as repair costs of the equipment.

In the above specification and drawings, the invention has only been described by way of example and it is by no means restricted thereto. It is substantial that the quality of the web to be coated is monitored with cameras operating within the infrared region either such that the web exiting the paper machine is monitored before coating or the quality of the coating material of the coated paper is monitored before calendering substantially continuously such that the manufacturing process of the paper web product can be adjusted either on the actual paper machine or in the treatment thereafter in order to obtain a product of as high quality as possible.

CLAIMS

1. A method for monitoring the quality of the paper web in a continuous process, wherein the paper web exiting the actual paper machine is conveyed for treatment, **characterized** in that the moving paper web is imaged with a thermal camera prior to and/or during the treatment substantially continuously in order to detect defects in the paper web and that on the basis of the detected defects the manufacturing process of the paper web product is adjusted.
2. A method as claimed in claim 1, **characterized** by monitoring the web that is calendered immediately upon manufacturing.
3. A method as claimed in claim 1 or 2, **characterized** by monitoring the web that in conjunction with the actual web manufacturing will be finally coated with a coating layer.
4. A method as claimed in any one of preceding claims 1 to 3, **characterized** by monitoring wet spots and patches in the web and/or wet streaks of the web.
5. A method as claimed in claim 3 or 4, **characterized** by monitoring the web before and/or after the coating of the web.
6. A method as claimed in any one of claims 1 to 5, **characterized** in that the imaging is performed within the infrared light spectrum of 3 to 12 micrometer in wavelength.
7. A method as claimed in any one of claims 1 to 6, **characterized** in that the imaging is performed with a video camera on a continuous basis.
8. A method as claimed in any one of claims 1 to 6, **characterized** in that the imaging is performed by taking still pictures at predetermined intervals on a substantially continuous basis.
9. A method as claimed in any one of preceding claims, **characterized** in that the image is continuously displayed on a monitor so as to enable continuous monitoring during the process.
10. A method as claimed in any one of preceding claims, **characterized** in that the image and/or images are stored in the memory for further analyzing.

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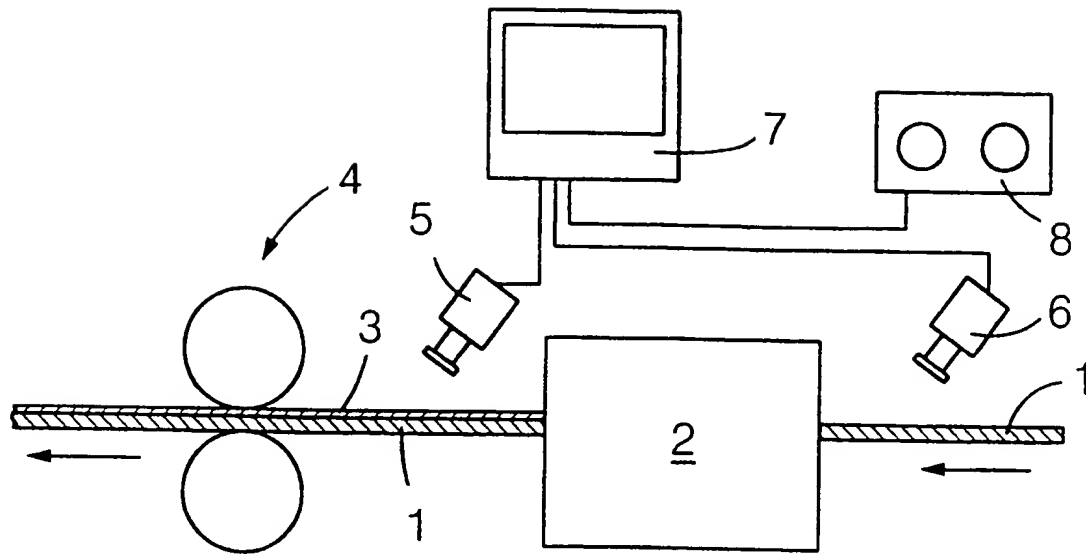


FIG.1

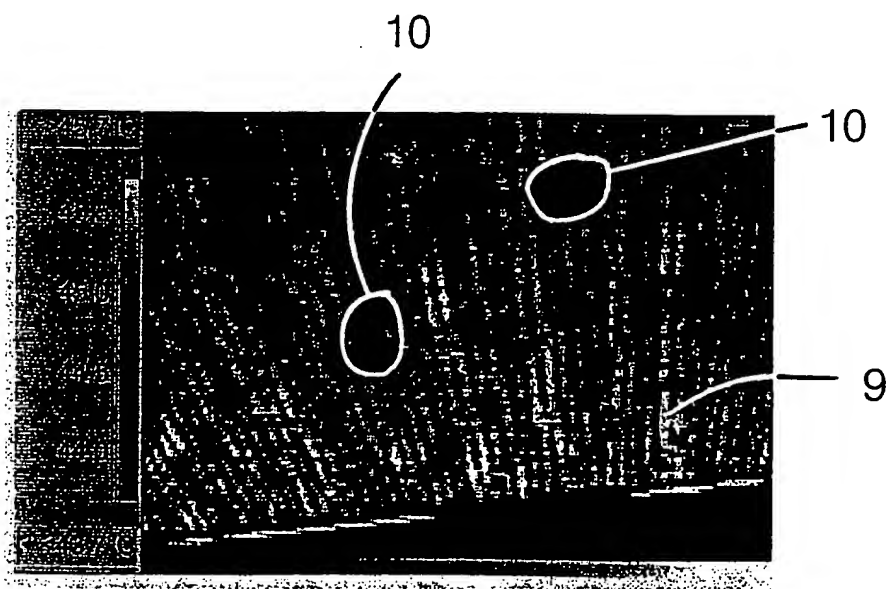


FIG.3

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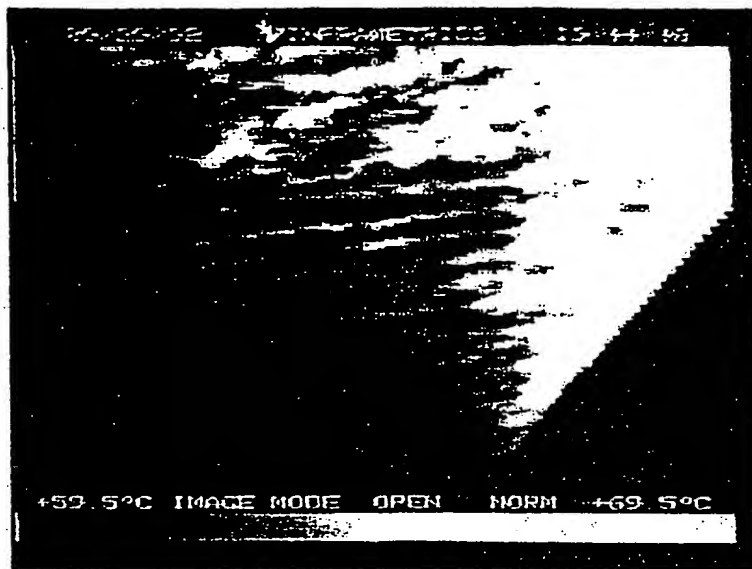


FIG. 2a

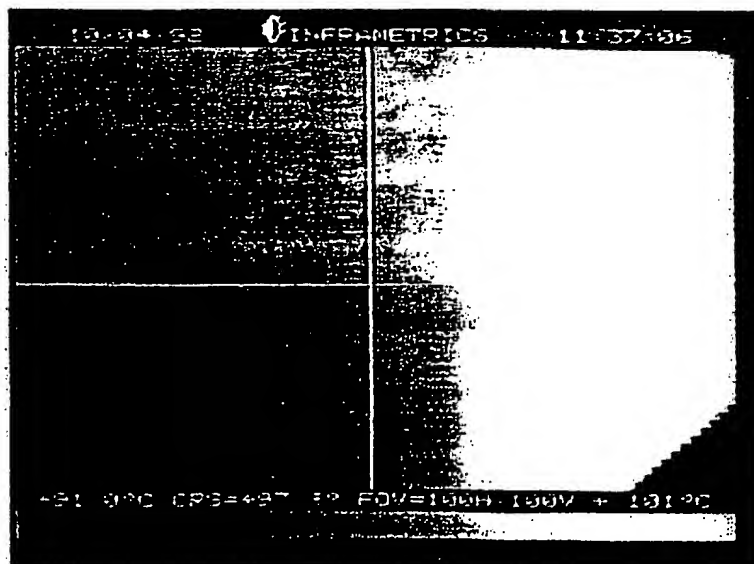


FIG. 2b

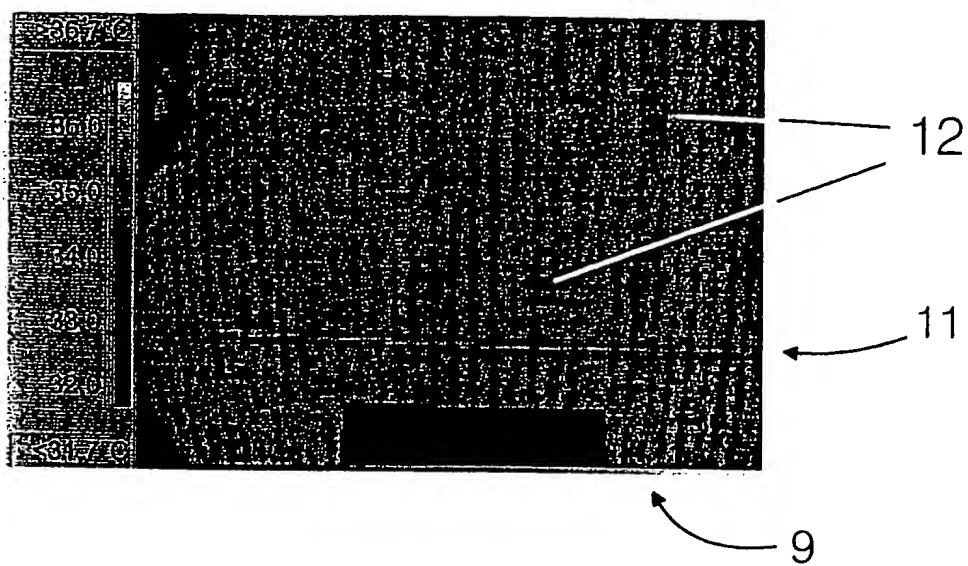


FIG. 4



FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI 00/00059

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: G01N 21/89 // G01N 33/34, D21G 9/00
According to International Patent Classification (IPC) or to both national classification and IPC

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Minimum documentation searched (classification system followed by classification symbols)

IPC7: G01N, D21G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5822070 A (H-R.SYRE), 13 October 1998 (13.10.98), column 2, line 47 - line 67, figure 1 --	1-10
X	US 5821990 A (R.J.RUDT ET AL), 13 October 1998 (13.10.98), column 5, line 5; 26 column 7, line 22 - column 8 line 63 --	1-10
X	TAPPI, Volume 67, No 12, 1978, DENNIS E.VICKERY ET AL, "INFRARED THERMOGRAPHY. An aid to solving paper machine moisture profile problems.", page 17 - page 20, see the whole article --	1-10

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Date of the actual completion of the international search

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5696591 A (R.B.BILHORN), 9 December 1997 (09.12.97), column 1, line 6 - line 10; column 4, line 52 - line 67 --	1-10
A	US 5118195 A (W.DOBIE), 2 June 1992 (02.06.92) --	1-10
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A	DE 19632988 C1 (STORA PUBLICATION PAPER AG), 22 January 1998 (22.01.98) -- -----	1-10

INTERNATIONAL SEARCH REPORT

Information on patent family members

02/12/99

International application No.

PCT/FI 00/00059

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